World Rabbit Science

World Rabbit Sci. 2005, 13: 3 - 16

NITROGEN AND PHOSPHORUS EXCRETION ON COMMERCIAL RABBIT FARMS: CALCULATIONS BASED ON THE INPUT-OUTPUT BALANCE

Maertens L.[*], Cavani C.[†], Petracci M.[†]

[*]Centre for Agricultural Research, Department of Animal Nutrition and Husbandry, Scheldeweg 68, 9090 Melle, Belgium.

[†]Department of Food Science, *Alma Mater Studiorum*, University of Bologna, Via S. Giacomo 9, 40126 Bologna, Italy.

Abstract: Manure is no longer exclusively considered as a fertiliser in areas with high densities of farm animals. Efforts are being made to reduce mineral excretion or to stimulate a more environmental-friendly use. In such a context, both from the governmental side and for the producer, a reliable calculation of the on-farm production is very useful. Based on the balance between input (feed) - output (produced rabbits, dead rabbits), the nitrogen and phosphorus on farm excretion have been calculated for different production systems, production levels and slaughter weights. For a closed farm (breeding + fattening) the most convenient expression of mineral excretion is per female on average present on the farm. The excretion amounts to 7.42 kg N and 4.76 kg P_2O_5 per doe/year on a commercial rabbit farm based on an average production/doe of 45 fatteners of 2.5 kg. The excretion decreases from 76 to 61 g N and from 48 to 40 g P_2O_5 /kg rabbit produced with increasing productivity of the farm (35 *vs* 50 delivered fatteners/doe/year, respectively). In an exclusively fattening unit (between 0.8 and 2.5 kg weight and a feed conversion ratio of 3.40), the excretion amounts to 38 g N and 26 g P_2O_5, per kg rabbit produced.

Key words: rabbits, nitrogen, phosphorous, excretion, farm.

INTRODUCTION

Mineral pollution of water and soils originating from animal production has become a major problem in several European countries. Manure is no longer considered as a fertiliser, but as a polluter of the environment. Agricultural ammonia production is

Correspondence: L. Maertens
E-mail: l.maertens@clo.fgov.be

partly responsible for the acidification problems (acid rains) and high levels of nitrite, phosphate and heavy metals (Fe, Mn, Pb, etc) are linked with decreasing quality of surface and drinking water. Besides EC-directives (e.g. N-directive 91-676 CEE), in several countries or areas having a high density of animal production measures are taken to control or to reduce the excretion of mainly nitrogen (N) and phosphorus (P). For example in The Netherlands and Belgium (Flemish region) farmers have a maximum quota of N and P, based on their previous production data, which they are allowed to produce on their farm. Above this quantity, farmers have to pay high taxes. Moreover, the production data are used for a responsible spreading of the excreta on agricultural land. In several other countries (e.g. Italy) local legislation is expected in the very near future.

With this in view, both for the governmental and the farmers, a reliable calculation of the excretion is a tool for a more optimal use of the excreta. Until now, only partial or divergent data are available for rabbits (VAN EERDT and GROOT-SEVERT, 1994; MAERTENS, 1999; CORPEN, 2000). Some of the differences can be explained by the diverse forms in which they are expressed (e.g. per fattening rabbit or per doe) or by the production type or level (closed farm or fattening only).

The present paper intends to propose a calculation on a reliable basis of the N and P excretion for different rabbit production systems, capable of being used as a tool for the prediction of the real on-farm excretion.

MATERIALS AND METHODS

The calculations are based on the principle (hypothesis) that the excretion is the difference between the input and the retention in the body. The balance for a mineral X during a certain period (commonly calculated on a yearly basis) can than generally be expressed as:

[Dietary level of X(g/kg)×feed consumption (kg)]–[content of X in the body(g/kg) ×weight of the body(kg)]=excretion of X(g)

Calculations are performed for the 3 different types of rabbit production systems: closed farms (reproduction + fattening unit), only breeding (weanlings are sold) and only fattening. The different data necessary to calculate the excretion are presented for these 3 types of rabbit units. For a closed farm, the excretions per average doe are calculated including those of the fatteners, young reproduction stock and males (if any) because production data are also expressed per average doe.

Dietary levels

The N and P levels of the diet can be analysed quite easily. However, according to the feed batch, differences occur even with the same raw material composition. For the calculations, we have taken an average crude protein level of 175 g/kg for breeding does and 160 g/kg for fatteners, based on the recommendations of De Blas and Wiseman (1998) and also some recent publications (Xiccato et al., 2003 and 2004; Castellini et al., 2003). This means 28.0 and 25.6 g N/kg, respectively. Because fatteners consume about 2/3 of the feed in a closed farm, an average CP level of 165 g/kg or 26.4 g N/kg is used.

The phosphorus levels in rabbit diets are in the range of 4.5-7.5 for breeding does and 3.5-7.0 for fattening rabbits (Mateos and De Blas, 1998). Based on these data and on the calculated data of commercial diets, the following average dietary levels will be used for the calculations: 6.60 and 6.40 g P/kg for does and fatteners, respectively and 6.47 g P/kg as average for a closed farm.

Feed consumption

The feed consumption depends on a lot of factors, the most important being the age of the rabbits, the category (reproducing – fattening), the market weight, the reproduction level (number of weaned rabbits/doe), the strain and the dietary energy content. However, at the farm level, all these factors are included in the global feed conversion ratio (FCR). Moreover, in the global FCR of the farm the effect of mortality is also included. Therefore, for a closed farm an easy and reliable calculation of the excretion can be carried out based on the average production per doe and per year and the global FCR. Both data are quite easy to determine and to control at the farm level.

Table 1: Global feed conversion ratio for different slaughter weights and number of rabbits produced/doe/year.

No rabbits produced/doe/year	35	40	45	50
Slaughter weight (kg)	Global feed conversion ratio			
2.0	3.53	3.38	3.27	3.20
2.25	3.76	3.58	3.44	3.34
2.50	4.11	3.84	3.70	3.52
2.75	4.54	4.25	3.98	3.74

In Table 1, average farms FCR's are presented according to production level and slaughter weight (adapted from MAERTENS and VILLAMIDE, 1998). These values will be used for the further calculations because they are still in line with published French field conditions. For a slaughter weight of 2.43 kg, the average global FCR of 998 French farms was 3.70 in 2000 (GUERDER, 2002). In Spain the FCR was 3.66 (mean of 296 farms) in 2002, however, average slaughter weight was limited to 2.06 kg (RAMON et al., 2004). On the other hand, in Belgium the FCR reached 4.14 in 2002 (mean of 24 farms) for a slaughter weight of 2.64 kg (HERTOGS, 2003; personal communication). This worse FCR could be partially explained by the enteropathy problems caused by an average post weaning mortality rate of 17.2%.

Nitrogen content of rabbits

In the literature, data are not available for the whole body composition in contrast to the empty body (EB) composition. Therefore an estimate is proposed based on the EB composition and considering that the average N content in the gut is comparable to the dietary composition.

According to these literature data, the N content in the EB of slaughter rabbits is on average around 32.5 g/kg for rabbits with a live weight of ± 2.5 kg. Based on the works of FRAGA *et al*. (1983), SZENDRŐ *et al*. (1998) and XICCATO *et al*. (2003), the N content increased with increasing live weight (LW) or age. This relationship is expressed in the following equation:

N (g/kg): 28.3 + 0.93 x LW (kg) (Szendrö *et al*., 1998)

or for each 0.1 kg difference in LW the N content of the EB changes with 0.093 g/kg.

The difference between LW (no fasting) and EB weight is around 13% for fatteners (Maertens *et al*., 1997). If we assume that the average N content in the gut is the same as in the diet (28.4 g/kg DM) with an average DM content of 20% (Lebas *et al*., 1997) than the N-content of a standard rabbit at slaughter (2.5 kg) is:

32.5 x 0.87 + 0.13 x (28.4 x 0.20) = 29.0 g N/kg LW

If the average slaughter weight differs from this standard weight (2.5 kg), per 0.1-kg difference a correction of 0.080 g N/kg should be used.

Based on Table 2, the N content of the EB of does is in quite the same range as fatteners. But because the difference between EB and LW is around 10% for does (Rommers *et al*., 2001a; Xiccato *et al*., 2004), the N content of does is:

32.5 x 0.90 + 0.10 x (31.10 x 0.20) = 29.9 g N/kg LW

Phosphorus content of rabbits

There are very few data available concerning the P content of rabbits. In empty bodies, Ferreira *et al*. (1996) determined 5.14 g P in rabbits of 2.4 kg. If we use the same recalculation to LW as proposed for the N content, than the P content of a standard rabbit at slaughter (2.5 kg) is:

5.14 x 0.87 + 0.13 x (7.36 x 0.20) = 4.66 g P/kg LW

Van Eerdt and Groot-Severt (1994) used a body content of 6 g/kg LW in their calculations. However, the values of Ferreira *et al*. (1996) were confirmed in our slaughter rabbits of 2.5 kg LW. The average P content was 5.01 ± 0.36 g/kg LW (Maertens, not published). Therefore for the calculations, an average P content of 5.0 g P/kg LW will be used. Since no distinguishing data are available for does and fatteners, a similar P content will be assumed.

Table 2: N content (g/kg) in the empty body of fatteners and does.

Rabbits	Weight (kg)	N (g/kg)	Reference
Fattening			
	1.2	29.44	SZENDRÖ *et al.,* 1998
	1.8	29.77-29.92	XICCATO *et al.,* 2003
	± 2.0	32.85	DEHALLE, 1981
	2.0	30.6	FRAGA *et al.*, 1983
	2.0	31.39	GARCIA *et al.*, 1993
	2.25	31.3	FRAGA *et al.*, 1983
	2.3-2.4	32.98-33.41	MAERTENS *et al.*, 1998
	2.50	31.2	FRAGA *et al.*, 1983
	2.5	32.03	GARCIA *et al.*, 1993
	2.6	29.77[1]	MAERTENS *et al.*, 1997
	± 3.3	33.44	SZENDRÖ *et al.*, 1998
Nulliparous does:			
At insemination	± 4.0	32.32	XICCATO *et al.*, 1999
	± 4.0	31.1-32.5	ROMMERS *et al.,* 2001a
5 days post insemination	3.7-4.2	31.23-30.32	ROMMERS *et al.*, 2001b
At kindling	± 4.0	29.76	XICCATO *et al.*, 1999
Primiparous does:			
At weaning	± 4.0	33.92	XICCATO *et al.*, 1999
	± 4.5	32.0-32.9	ROMMERS *et al.*, 2001a
Multiparous does:			
At 3rd parturition	3.75	32.32	XICCATO *et al.*, 2004

[1] Only stomach and caecum of the body were emptied

RESULTS

Estimations of the on-farm N and P excretions for closed farms and exclusively fattening or breeding units are presented below.

For a closed farm

The input on a closed farm is under normal production circumstances limited to the feed consumption. Minerals leave the farm however, in the form of i) the produced fatteners and also ii) are sold as non-productive females and iii) removal of dead rabbits.

A production level of 45 fattening rabbits produced (sold) with an average weight of 2.5 kg (or 112.5 kg/average doe) and a farm feed conversion ratio of 3.7 (Table 1) will be used as an example for the calculation. Dietary N and P content are assumed to be 26.4 and 6.47 g/kg, respectively. The replacement level of does on a commercial farm is on average 120% and taking into account that 2/3 of them are sold, this means that 0.8 x 4.0 kg = 3.2 kg is sold as old females/doe on average present on the farm.

The average mortality rate of fatteners used in our calculation example is 10%. However they do not yet have slaughter weight when they die. Therefore in our example they are counted only as 50% of the slaughter weight: 0.10 of 112.5 x 0.50 = 5.625 kg. The dead females are estimated as 1/3 x 1.20 x 4.0 or 1.6 kg, or in total 7.23 kg rabbit is removed/female/year due to mortality. Based on the input and output data and taking the production data of this “average” farm the balance can be drawn up (Table 3).

For an exclusively fattening unit

Rabbits are actually almost exclusively weaned between 4 and 5 weeks of age. For our calculation example, an average weaning weight of 0.8 kg and a slaughter weight of 2.5 kg is proposed with a feed conversion ratio of 3.40 during the fattening period. This means that 5.78 kg feed is consumed per rabbit (Table 4). In this FCR, a mortality rate of 8% is considered. This value is somewhat lower than the losses

proposed in a closed farm because an initial selection has taken place that excludes weanlings with disease symptoms or with too low weight.

A second source of mineral input on a fattening farm is through the weaned rabbits bought. Their N content is corrected according to their reduced weight. Dead rabbits are assumed to have on average 50% of their slaughter weight or they are counted as 2.5 kg x 0.5 x 0.08 = 0.1 kg/initial rabbit with a N content of 28.0 g/kg.

The excretion for an exclusively fattening farm can be expressed per fattening rabbit, per kg fattening rabbit as well as per fattening place. In this last expression, it is assumed that 7 batches of fatteners can be housed in the same cage per year.

For an exclusively breeding unit

The calculation will be based on the same farm data as those proposed for a closed farm: 45 produced fatteners/doe/year increased by the assumed mortality of 10%. The sold weanlings are counted with an average weight of 0.8 kg.

There are different replacement methods for the reproduction stock, e.g. one day old kits, young females or a small group of grandparent stock. Accordingly to

Table 3: Calculation of the N and P excretion in a closed farm.

	(kg)	N content (g/kg)	N (kg)	P content (g/kg)	P (kg)
Input:					
Feed	416.25	26.4	10.99	6.47	2.693
Removed:					
Slaughtered rabbits	112.50	29.0	-3.26	5.0	-0.563
Old rabbits	3.20	29.9	-0.10	5.0	-0.016
Dead rabbits	7.23	29.2	-0.21	5.0	-0.036
Excretion/doe/year			7.42		2.078[1]

[1]or 4.76 kg P_2O_5.

the method applied, differences in the global maternity FCR will occur. However, for the calculation we will not make a distinction because i) the differences in FCR due to the replacement method are limited; ii) we do not have data to make a reliable distinction. In our example (Table 5), a global FCR of 3.7 will be used although even at a fixed production level, a lot of factors (e.g. weaning age, diet, mortality, strain,…) have an important positive or negative impact.

The feed consumption expressed per female/year can be deduced from the sum of produced weanlings (0.8 kg x 50 = 40 kg) and sold females (3.2 kg, see closed farm calculation) and the FCR, being 43.2 kg x 3.7 = 159.84 kg.

The output of minerals in the carcasses of the dead rabbits mainly originates from the females and can be estimated as 1.6 kg/female (see closed farm). Mortality of young is mainly at an early stage and around 20% (GUERDER, 2002). An average weight of these carcasses does not exceed 0.20 kg or their total weight is estimated as 2.5 kg/female/year.

Table 4: An example for the calculation of the N and P excretion in a fattening unit.

	(kg)	N content (g/kg)	N (kg)	P content (g/kg)	P (kg)
Input:					
Feed	5.78	25.6	0.148	6.40	0.0370
Weaned rabbits	0.80	27.6	0.022	5.0	0.0040
Removed:					
Slaughtered rabbits	2.50	29.0	-0.073	5.0	-0.0125
Dead rabbits	0.10	28.0	-0.003	5.0	-0.0005
Excretion/fattener/year			0.094		0.0280[1]
Excretion/kg produced			0.038		0.0114[2]
Excretion/fattening place[4]			0.658		0.1961[3]

[1]or 0.0641 kg P_2O_5, [2]or 0.026 kg P_2O_5, [3]or 0.449 kg P_2O_5.
[4]7 batches per cage and year.

Table 5: An example for the calculation of the N and P excretion in an exclusively breeding unit.

	(kg)	N content (g/kg)	N (kg)	P content (g/kg)	P (kg)
Input:					
Feed	159.84	28.0	4.48	6.60	1.055
Removed:					
Weaned rabbits	40.0	27.6	-1.10	5.0	-0.200
Old rabbits	3.2	29.9	-0.10	5.0	-0.016
Dead rabbits	4.1	28.3	-0.12	5.0	-0.021
Excretion/doe/year:			3.16		0.818[1]

[1]1.87 kg P_2O_5.

If replacement is exclusively by the introduction of young females (10-11 weeks old), then a correction has to be made on the input side. Per female, 1.2 young females of 2.5 kg have to be considered with an N and P content of 29.0 and 5.0 g/kg, respectively. This leads to an increase of the N and P excretion/doe/year of 0.087 kg N and 0.034 kg P_2O_5.

DISCUSSION

Commercial rabbitries are mostly both breeding and fattening units. Therefore in our opinion, the most convenient expression of mineral excretion is per female on average present on the farm. Both farm productivity and number of females are generally well known data, easily to collect and to control at the farm level. Complicated calculations are avoided and moreover the excretion of all rabbits present on such farms (young reproduction stock, females, young before weaning, fatteners and eventually males) is considered.

The average excretion per doe calculated (Table 3) is somewhat lower than the values of VAN EERDT and GROOT-SEVERT (1994), 8.70 and 4.85 kg for N and P_2O_5, respectively. The explanation can be found in the production level (-7%) and FCR

(+5%) used for their calculation. Besides the different data used for the calculation, the absence of the correction for dead rabbits explains the difference with our earlier mentioned values of 8.21 kg N and 4.77 kg P_2O_5 (Maertens, 1999). On the other hand, the data proposed by the French committee Corpen (2000) greatly underestimates N-excretion. For a quite comparable production level (45.8 rabbits/doe/year and a FCR of 3.83), the N-excretion proposed was only 3.05 kg, while the P_2O_5 was close to our calculated value (4.19 and 4.76 kg, respectively). Moreover, a higher P excretion than N excretion seems unrealistic considering that the dietary P content is at least 4 times lower than the dietary N content.

Based on the calculation presented in Table 3, the excretion can be easily calculated for a different production level, dietary content or slaughter weight. In Table 6, examples of excretion data are presented based on data given in Table 1. Nutrient concentration and output in dead rabbits are held at the same level.

Above a weight of 2.5 kg, the FCR is higher than 5 (Laffolay, 1985), and as a consequence, the global FCR increases quickly (Table 1). Moreover, the impact of increasing slaughter weight on the N and P excretion seems to be larger than the increase in the production level (Table 6).

The excretion expressed per doe increases with increasing productivity and slaughter weight (e.g. from 4.21 to 9.25 kg N). However, if expressed per fattening rabbit or per kg produced rabbit, then a highly productive farm produces much less N and P in the manure (more efficient). For example, at a fixed slaughter weight of 2.5 kg, the N excretion/kg rabbit produced is 76, 71, 66 and 61 g and the P_2O_5 is 48, 45, 42 and 40 g/kg rabbit produced for a production level of 35, 40, 45 and 50 rabbits, respectively.

Based on these data, when using an average excretion/female/year (Table 6), the excretion of highly productive farms will be underestimated. On the other hand, when the unit of expression is per fattening rabbit (or kg rabbit produced), the excretion of highly productive farms will be overestimated and those of less productive farms underestimated.

Table 6: Estimation of N and P excretion in a closed farm according to production level (no. of rabbits produced) and slaughter weight (kg) of the fatteners.

Produced/doe/year	35		40		45		50	
Slaughter weight	N	P_2O_5	N	P_2O_5	N	P_2O_5	N	P_2O_5
2.0	4.21	2.74	4.54	2.97	4.89	3.21	5.28	3.48
2.25	5.24	3.37	5.60	3.62	5.97	3.88	6.37	4.16
2.5	6.65	4.21	6.93	4.43	7.42	4.76	7.68	4.97
2.75	8.42	5.25	8.82	5.55	9.08	5.76	9.25	5.93

The above calculated excretion data are still estimates based on average data. Each farm is different according to its own figures. The calculation of the on-farm excretion can be improved i) when a correct calculation is made of the feed quantities consumed and the delivered kg of rabbits and carcasses ii) by using chemical analyses of the feed. With this data an accurate N and P on-farm excretion can be obtained using the same calculation basis as for the input-output balance presented in Tables 3, 4 and 5 for a closed farm, breeding or exclusively fattening farm, respectively.

Finally, knowing the excretion data and the main factors of variance can be a stimulant to using low protein and phosphorus diets that better meet the requirements of the different categories of rabbits (MAERTENS *et al*., 1997; XICCATO et al., 2003). In fact, the intake is about two thirds of the excretion and has a higher impact on the balance than the output. In this way, excretion can be reduced and consequently also environmental pollution in areas with an excess of manure production.

REFERENCES

CASTELLINI C., DAL BOSCO A., MUGNAI C. 2003. Comparison of different reproduction protocols for rabbit does: effect of litter size and mating interval. *Livestock Production Sci., 83, 131-139.*

CORPEN 2000. Les normes “CORPEN” pour les élevages cunicoles. *Cuniculture, 27, 36-37.*

De Blas C., Wiseman J. 1998. The Nutrition of the rabbit. *CABI Publishing, CAB International, Wallingford Oxon (UK), 255-272.*

Dehalle C. 1981. Equilibre entre les apports azotés et énergétiques dans l'alimentation du lapin en croissance. *Ann. Zootech., 30, 197-208.*

Ferreira R.G., Carregal R.D., Resende K.T. 1996. Net energy, protein and macrominerals requirements for 70 to 120 day old female rabbits. *Proc. 6th World Rabbit Congress, Toulouse (France), Vol. 1, 171-174.*

Fraga M.J., De Blas J.C., Pérez E., Rodriguez J.M., Pérez C.J., Galvez J.F. 1983. Effect of diet on chemical composition of rabbits slaughtered at fixed body weights. *J. Anim. Sci., 56, 1097-1104.*

Garcia G., Galvez J.F., De Blas J.C. 1993. Effect of substitution of sugarbeet pulp for barley in diets for finishing rabbits on growth performance and on energy and nitrogen efficiency. *J. Anim. Sci., 71, 1823-1830.*

Guerder F. 2002. Résultats 2000 de la GTE Renaceb. Conduites en bandes: de bons résultats économiques. *Cuniculture, 29, 117-122.*

Hertogs I. 2003. Technische resultaten van Belgische konijnenbedrijven. *Personal communication.*

Laffolay B. 1985. Croissance journalière du lapin. *Cuniculture, 12, 331-335.*

Lebas F., Coudert P., De Rochambeau H., Thébault R.G. 1997. The Rabbit: Husbandry, health and production. *Ed. FAO, Rome (Italy), p.20.*

Maertens L., Luzi F., De Groote G. 1997. Effect of dietary protein and amino acids on the performance, carcass composition and N-excretion of growing rabbits. *Ann. Zootech., 46, 255-268.*

Maertens L., Villamide M.J. 1998. Feeding systems for intensive production. *In: De Blas C., Wiseman J. (eds), The Nutrition of the rabbit. CABI Publishing, CAB International, Wallingford Oxon (UK), 255-272.*

Maertens L., Cavani C., Luzi F., Capozzi F. 1998. Influence du rapport protéines/énergie et de la source énergétique de l'aliment sur les performances, l'excrétion azotée et les caractéristiques de la viande des lapins en finition. *Proc. 7èmes Journ. Rech. Cunicole, 13-14 Mai 1998, Lyon (France), 163-166.*

Maertens L. 1999. Towards reduced feeding costs, dietary safety and minimal mineral excretion in rabbits: a review and opinion article. *World Rabbit Sci., 7, 65-74.*

Mateos G.G., De Blas J.C. 1998. Minerals, vitamins and additives. *In: De Blas C., Wiseman J. (eds), The Nutrition of the rabbit. CABI Publishing, CAB International, Wallingford Oxon (UK), 145-176.*

Ramon J., Rafel O., Piles M., 2004. Resultados de gestión en España. GTE 2002: Algo Falla. *Boletin de Cunicultura*, *133, 24-28.*

Rommers J.M., Kemp B., Meijerhof R., Noordhuizen J.P.T.M. 2001a. The effect of litter size before weaning on subsequent body development, feed intake, and reproductive performance of young rabbit does. *J. Anim. Sci., 79, 1973-1982.*

Rommers J.M., Meijerhof R., Noordhuizen J.P.T.M., Kemp B. 2001b. Effect of

different feeding levels during rearing and age at first insemination on body development, body composition, and puberty characteristics of rabbit does. *World Rabbit Sci., 9, 101-108.*

Szendrö Zs., Kenesssey A., Jensen J.F., Jensen N.E., Csapo J., Romvari R., Militsits G. 1998. Effect of genotype, age, body weight and sex on the body composition of growing rabbits. *World Rabbit Sci., 6, 277-284.*

Van Eerdt M.M., Groot-Severt M.T.M. 1994. Werkgroep Uniformering Berekening Mest- en Mineralencijfers. Standaardcijfers pluimvee, pelsdieren en konijnen, 1990 t/m 1992. *IKC uitgave (The Netherlands), p.58.*

Xiccato G., Bernardini M., Castellini C., Dalle Zotte A., Queaque P.I., Trocino A. 1999. Effect of postweaning feeding on the performance and energy balance of female rabbits at different physiological states. *J. Anim. Sci., 77, 416-426.*

Xiccato G., Trocino A., Sartori A., Queaque P.I. 2003. Effect of weaning diet and weaning age on growth, body composition and caecal fermentation of young rabbits. *Anim. Sci., 77, 101-111.*

Xiccato G., Trocino A., Sartori A., Queaque P.I. 2004. Effect of parity order and litter weaning age on the performance and body energy balance of rabbit does. *Livestock Prod. Sci., 85, 239-251.*